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FINAL REPORT

Assessment of Geology, Energy, and Minerals (GEM) Resources

PROCEDURES FOR THE ASSESSMENT OF GEM RESOURCES

Prepared for

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

March 1983

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Procedures For
The Assessment of
Geology, Energy, and Minerals (GEM) Resources

Prepared For:

United States Department of the Interior
United States Bureau of Land Management
Scientific Systems Development Branch

By

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BLM Contract No.: YA - 553 - CT2 - 1042

March, 1983

This report was prepared as part of a Phase I Assessment of GEM Resources within designated Wilderness Study Areas in Oregon, Idaho and Nevada.

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All members of the panel of experts provided valuable input into these assessments of GEM resources for each of the GEM Resource Areas (GRAs). Their professional approach to the problems and their interpretations of available literature and data form the foundation upon which the assessments for this project are based. We are grateful for their efforts and skills in this project. The panelists and their area of expertise are:

- Dr. Antonius Budding - Oil Shale and Tar Sands
- Mr. Raymond Corcoran - Field Verification
- Dr. James Firby - Paleontology
- Mr. Ralph Mason - Coal
- Mr. Richard Miller - Uranium and Thorium
- Mr. Vernon Newton - Oil and Gas
- Mr. Herbert Schlicker - Industrial Minerals and Geologic Hazards
- Dr. Walter Youngquist - Geothermal
- Dr. Paul Weis - Metals and Non - Metals.

Mr. Edwin Montgomery provided valuable insight and assistance in structuring the project and these reports in order to best serve the purposes of the Bureau of Land Management. We greatly apppreciate his assistance.

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Mr. Tom Mitchell assisted in the stream sediment sampling program. Bondar - Clegg provided the geochemical analysis of stream sediment samples.

Ms. Pamela Ruhl provided clerical and editorial assistance throughout the project. Ms. Sara Mathews assisted with occurrence information and drafting. Mr. Philip R. Jones and Mr. Michael A. Becker produced all documents relating to the project using TERRADATA's word processing and document production systems.

EXECUTIVE SUMMARY

This is a report on the procedures used by TERRADATA in a Phase I assessment of the potential for geology, energy, and mineral (GEM) resources within selected groups of Wilderness Study Areas (WSAs). There are 27 separate reports for GEM resource areas (GRAs) in Oregon, Idaho and Nevada. There are 16 GRAs in Oregon, six in Idaho and five in Navada. All of the assessments were part of the regional GEM resources project. The United States Department of the Interior, Bureau of Land Management (BLM) is specifically concerned with lands that have been designated as WSAs. Information developed by this project will be used along with other information to develop recommendations from the Director of the BLM to the Secretary of the Interior regarding the ultimate disposition of the WSAs. The Secretary, after receiving the Director's recommendations, may recommend some or all of the areas to Congress for designation as Wilderness Areas. Prior to legal designation by Congress, the United States Geological Survey (USGS) and the United States Bureau of Mines (USBM) must make an official report on GEM resources for each area nominated by the Secretary. The informaton developed by this project will assist in the preparation of that report.

This report is a general summary of the procedures used in this project. Details specific to each GRA are found in the individual reports. Supporting information for each GRA is contained in the corresponding GRA file located in the appropriate BLM District Office.

The primary purposes of this study are to identify environments favorable for the occurrence of GEM resources and to classify the land according to the degree of favorability for those GEM resources. Assessment of the GEM resources for this project consisted of an analysis and interpretation of all readily available data by a panel of experts. The panel consisted of professionals whose expertise is with different commodities as well as with the general geology of the study region. The panelists and their specific areas of commodity expertise were:

- Dr. Antonius Budding, Professor of Geology, New Mexico Institute of Mining and Technology — Oil Shale and Tar Sands Resources.
- Mr. Raymond Corcoran, former Director of the Oregon Department of Geology and Mineral Industries — Field Verification Specialist.

- Dr. James Firby, Professor of Geology, University of Nevada, Reno — Paleontological Resources.
- Mr. Ralph Mason, former Oregon State Geologist — Coal Resources.
- Mr. Richard Miller, former U.S. Department of Energy Regional Geologist — Uranium and Thorium Resources.
- Mr. Vernon Newton, Jr., Consulting Geologist — Oil and Gas Resources.
- Mr. Herbert Schlicker, Consulting Geologist — Industrial Minerals Resources and Geologic Hazards.
- Dr. Paul Weis, former USGS Geologist — Metals and Non-Metals Resources.
- Dr. Walter Youngquist, Consulting Geologist — Geothermal Resources.

Seven tasks were undertaken for this project. They were:

Task 1: Literature Search and Data Collection
This task was carried out by TERRADATA personnel with the assistance and guidance of the panelists.

Task 2: Literature and Data Compilation
TERRADATA established GEM Resource Area (GRA) databases in conjunction with the BLM. GRAs are information management units that contain one or more WSAs.

Task 3: Review and Interpretation
This task was undertaken by the expert panelists. Using specific geologic recognition criteria and their commodity and geographic specific knowledge, the panelists interpreted the data and information in light of environments favorable for the occurrence of GEM resources in the GRAs and contained WSAs.

Task 4: Field Verification
Selected GRAs were studied in the field for supportive and/or refutive evidence. Results were added to the GRA databases for re-interpretation and re-evaluation.

Task 4A: Geochemical Sampling and Analysis
A brief geochemical survey of GRAs selected by the BLM was carried out by TERRADATA personnel and Bondar - Clegg Analytical Laboratory. This geochemical program was limited to four GRAs in southeastern Oregon.

Task 5: Re-Evaluation
TERRADATA's panelists reviewed new data gathered during the field verification and, where appropriate, modified their original assessments.

Task 6: Report Preparation
TERRADATA personnel integrated the compiled databases and panelists conclusions into a single, comprehensive report for each GRA. The reports were then reviewed by the panelists.

The multidisciplinary approach used in Task 3, review and interpretation, assures the BLM that the GEM resource evaluations are based on extensive individual commodity knowledge and pertinent geographic expertise. The results of this project rely very heavily on the evaluations by the panelists. In an effort to maintain continuity among commodities and GRAs and among different evaluation projects of this type, all lands within the study region have been classified by the panelists, as prescribed by the BLM, according to the degree of favorability for GEM resources and the level of confidence in the favorability classification.

The favorability rating scale ranges from one to four, with one being unfavorable and four being most favorable. Favorability classes of two and three represent low and moderate favorability, respectively. Confidence levels range from A to D with A being low confidence and D being high confidence. The confidence levels are directly related to the quantity and quality of information available for determination of the favorability classes.

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1. INTRODUCTION

This project involves an assessment of the geology, energy, and mineral (GEM) resources potential in selected Wilderness Study Areas (WSA) in southeastern Oregon, southwestern Idaho, and northeastern Nevada.

The Federal Land Policy and Management Act of 1976 (FLPMA) assigns to the United States Bureau of Land Management (BLM) the responsibility of planning for and managing the resources on the public lands under its jurisdiction. To accomplish this, the BLM must inventory the resources of these lands and develop and implement multiple-use plans. These resources include range lands, minerals, recreation, wildlife, and others.

GEM resources, one of the resource categories of concern to the BLM, include all energy and mineral resources and areas of special geological value. The lands under the BLM's jurisdiction include lands managed by the BLM, certain lands controlled by other Federal agencies and lands whose surface rights are privately owned but whose mineral rights belong to the Federal Government.

1.1 PURPOSE

The purpose of the project for which this Procedures Report was prepared is to make a preliminary (Phase I) assessment of GEM resources within selected WSAs in Oregon, Idaho, and Nevada. BLM District Managers and State Directors will use the results of this project along with other information in making the decision regarding which WSAs are suitable to be recommended as possible Wilderness Areas. Based on these recommendations and, as required by Section 603 of FLPMA, the suitable WSAs will be evaluated by the USBM and the USGS for their mineral value. This must be done before they can be recommended to Congress for consideration as Wilderness Areas. These reports will be useful in such appraisals. Under the Wilderness Act, only Congress has the authority to designate Wilderness Areas.

2. SCOPE OF THE PROJECT

There are 27 GRAs and 27 technical reports of GEM resources within the study region. The study region, as shown in Figure 2-1, includes 68 WSAs that have a combined area of 2,145,363 acres. Seven of the WSAs are in northeastern Nevada, 17 are in southwestern Idaho, and the remainder (44) are in southeastern Oregon(1,2,3)*. The specific GRAs indicated in this report are described in separate GRA reports. The largest WSA is in Oregon and comprises 223,970 acres whereas the smallest one (3,500 acres) is in Idaho.

The commodities considered in this assessment are:

- Metals (excluding Uranium and Thorium)
- Non-Metals
- Oil and Gas
- Oil Shale and Tar Sands
- Geothermal
- Uranium and Thorium
- Coal
- Industrial Minerals
- Paleontological Resources
- Geologic Hazards
- Educational and Scientific Localities

The assessment of GEM resources for this project consisted of an interpretation of existing literature and information by experts knowledgeable in both the geographic area and specific commodities. A restricted field verification and a limited stream sediment geochemical sampling and analysis program were carried out. It is possible that the assessment would be different if detailed field exploration, geochemical sampling, and exploratory drilling were undertaken.

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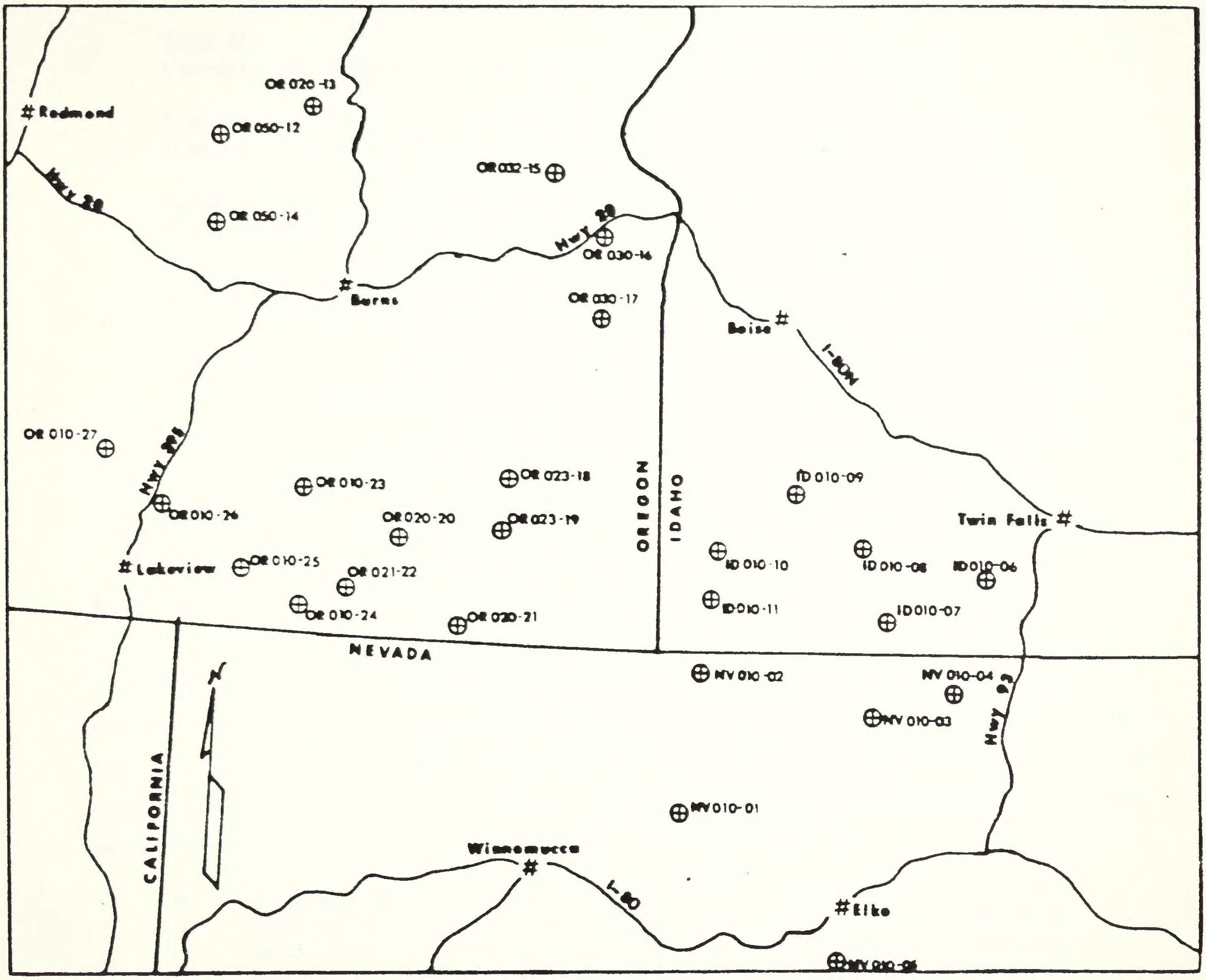
* In this report, citations are superscripted numbers. They refer to bibliographic entries listed in Appendix A, References Cited.

FIGURE 2-1

GRA Location Map

⊕ = GRAs in this project



3. METHODS

The process of assessing the GEM resources potential within the GRAs of this study region consisted of seven separate tasks. These are:

Task 1:
Literature Search and Data Collection

Task 2:
Compilation of Data and Organization of Database by GRA

Task 3:
Analysis and Interpretation of Database

Task 4:
Field Verification

Task 4A:
Stream Sediment Geochemical Sampling and Analysis

Task 5:
Re-interpretation of Database

Task 6:
Preparation of the GRA Technical Reports

A detailed description of each task follows.

3.1 TASK 1: LITERATURE SEARCH AND DATA COLLECTION

This task, carried out by TERRADATA personnel with the assistance and guidance of the expert panelists and BLM personnel, composed a comprehensive search of all available data and literature, published and unpublished. This search concentrated on information regarding GEM resources in the region and information about the geology of the region. Items on which this search concentrated were:

- Available geologic maps from the United States Geological Survey (USGS), the Oregon State Department of Geology and Mineral Industries, the Idaho Bureau of Mines and Geology, the Nevada Bureau of Mines and Geology, and the United States Department of Energy (DOE).
- Claims recorded with the BLM.
- Occurrence information (including mines, prospects, etc.) from the United States Bureau of Mines (USBM) (MILS data); the USGS (CRIB data and land classification maps); the DOE (NURE data); occurrence data from the Oregon State Department of Geology and

Mineral Industries, and the Idaho and the Nevada Bureaus of Mines and Geology.

- Available literature from the USGS, DOE, BLM, the Oregon State Department of Geology and Mineral Industries, and the Idaho and the Nevada Bureaus of Mines and Geology. Included are data obtained from questionnaires sent to colleges and universities within 500 miles of the study area, questionnaires to the BLM, USGS, and State geologists in the region, and personal communications with the BLM State and District geologists as well as other professional geologists known to be working in the area. Information regarding GEM resources was sought from private industry sources active in the project area.

These data were obtained through library searches and personal communications with governmental geologists. A significant source of relevant information was the team of panelists. Because they are knowledgeable in specific commodities and in the general geology of the area, the panelists were able to recommend specific literature and data sources relevant to the GEM resources assessment. The reports written by the panelists (See Task 3, Section 3.3, below) make specific reference to the dominant literature used in the evaluation. The relevant published literature on the GEM resources in the GRA are given in Appendix A, the References Cited section of this report. Many of these materials are the in GRA files in the BLM District Offices.

TERRADATA conducted a computerized bibliographic search using a vocabulary of key words in context (KWIC) suggested by the panelists and augmented by TERRADATA personnel. KWIC words used in the computer search consisted of:

- Geographic terms (county, state, region, province, subprovince)
- Authors' names
- Commodity names
- Publication source names
- Alteration type names
- Geologic ages
- Mineral names
- Element names.

Specific terms from this generic type KWIC vocabulary that were used as search strings in the bibliographic search are given at the top of each section of the computer-generated bibliography found in each BLM District master GRA file.

The search was conducted using the computer facilities of the MacKay School of Mines, University of Nevada, Reno. Over three million titles were scanned during the computer

search. This resulted in nearly 2,000 reference titles; many of these were discarded as being too general or irrelevant after evaluation by the panelists.

Significant sources of information used to locate and define the distribution and varieties of mineralization in the study area included MILS, CRIB, and NURE databases. Assistance was sought from mining and exploration companies known to be operating in the areas of the study. However, no response was received from these firms. The USBM's Mineral Industry Location Service (MILS) is part of the computerized Minerals Availability System (MAS); MILS is the location subsystem of MAS.

MILS sites are defined by Berg and Carrillo(4) as metallic or non-metallic occurrences, prospects, or mines; also included are geothermal wells and processing plants such as mills, smelters and refineries. Included in the MILS database are the name, location, mineral commodity, type of operation, bibliography, and cross-references for each property, occurrence, or prospect.

MILS data sources include published and unpublished information from the USBM, the USGS, the Mine Safety and Health Administration (MSHA) and state geologic survey reports. Additional information comes from exploration and mining companies and from journal papers.

Portions of computer-drawn map overlays of MILS data were obtained from the USBM Western Field Operation Center in Spokane, Washington. These are included in the GRA files for each of the GEM resource areas that contains at least one MILS occurrence. The overlays are at a scale of 1:250,000 and contain clustered MILS locations. They are accompanied by keyed computer printouts (contained in Appendix C of each GRA report). Information on the printout for each MILS location is self explanatory. The locations are clustered to avoid unnecessary cluttering and overlap on the maps. A cluster point may represent one or more MILS occurrence found within a ¼ inch radius on the map. This is roughly equivalent to a 1.0 mile ground distance radius at a scale of 1:250,000. The MILS map and legend pertaining to each GRA are given in Section 2 of the respective reports.

The USGS' Computerized Resources Information Bank (CRIB) is an information file of mineral resources, both domestic and foreign. CRIB is used by industry, universities, and state and Federal government agencies as a comprehensive source of mineral resources

Mineral Industries, and the Idaho and the Oregon Bureaus of Mines and Geology.

Available literature from the USGS, DOE, BLM, and [illegible] Departments of Geology and Mineral Industries, and [illegible] Bureaus of Mines and Geology [illegible] questionnaires [illegible] to collect and [illegible] [illegible] the [illegible] and [illegible] [illegible] as well as [illegible] [illegible] [illegible] [illegible]

[illegible] were obtained through [illegible] [illegible] significant [illegible] [illegible] that are [illegible] [illegible] [illegible] [illegible] [illegible]

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The USGS' Computerized Resources Information Bank (CRIB) is an information file of mineral resources, both domestic and foreign. CRIB is used by industry, universities, and state and Federal government agencies as a comprehensive source of mineral resources

data. Magnetic tapes of the CRIB data pertaining to this project study area were obtained from the USGS Office of Resource Analysis Branch, Menlo Park, California.

The CRIB file is oriented towards metallic and non-metallic mineral deposits and mineral commodities. However, an individual record may refer to a specific mine, prospect, or occurrence; a mining district, mining group, or mining area; or a single commodity or group of related commodities. General topics that are commonly included in the CRIB data are deposit name, location, commodity information, production information, and references for each CRIB record.

Input for the CRIB comes directly from the USGS and through cooperative exchange arrangements with the Tennessee Valley Authority (TVA), the United States Forest Service (USFS), the USBM, the United States Department of State (USDS), various state geological surveys, and other governmental agencies. For a more detailed explanation of CRIB see Caulkins and others, 1978(5).

CRIB data for the entire study area were examined by TERRADATA. CRIB localities within the GRAs were plotted on a mylar overlay at a scale of 1:250,000. Less than half of the GRAs in the study area contain CRIB sites. Nearly all CRIB sites occur outside WSA boundaries. A map of CRIB data is given in Section 2 of each GRA report, and is accompanied by a brief summary of the relevant CRIB site records. Where available, the summary contains the record number, the site name, location information, commodity and production information, and references.

The National Uranium Resource Evaluation (NURE) program of the DOE was a comprehensive program whose principal purpose was to estimate the amount of available uranium in the United States, excluding Hawaii. The NURE program consisted of three separate, but closely related investigation programs. These were:

- o Geological Investigation. This part of the NURE program consisted of literature search and field investigations designed to identify and delineate environments favorable for the occurrence of uranium deposits. The product of this investigation program was a series of folios in which was described the general geology of the study areas ($1^{o}x2^{o}$ NTMS quadrangles) and a discussion of the environments favorable for the occurrence of uranium deposits. Accompanying each folio is a series of maps that include a geologic map, and an uranium occurrence map, both of which were used in this project.

Contained within the folios are a series of Uranium Occurrence Reports (UORs). These describe the location, general geology, and type of uranium mineralization observed at located occurrences. Also available, from the Technical Library of the DOE in Grand Junction, Colorado, are a series of unpublished UORs and Preliminary Reconnaissance Reports (PRRs). PRRs are essentially unverified UORs and date back to the 1940's. All of these materials were used in the evaluation of uranium and thorium in the study region.

- Geochemical Investigation. An ambitious geochemical program was undertaken by the National Laboratories in which waters and stream sediments were sampled and analyzed for up to 40 different elements. The suite of elements for which analyses were run differed among the laboratories. From this program, called the Hydrogeochemical and Stream Sediment reconnaissance (HSSR) program, came a report and a magnetic data tape for each $1^{o}x2^{o}$ NTMS quadrangle studied. The stream sediment analytical data were used in this project. During this project the data were analyzed statistically and each element within the 90th percentile was noted for all sampling sites within each GRA. These data were used in interpreting favorable geologic environments. Concentrations of different elements all above the 90th percentile are interpreted as nonspurious geochemical anomalies. The specific data are contained within the appropriate GRA files.

- Geophysical Investigation. Aerial Radiometric and Magnetic Surveys (ARMS) were run by private subcontractors for the NURE program. Flight lines averaged approximately six miles apart at a corrected height of 400 feet above ground level. Spectral, total count radiometric, and magnetic data were collected. An interpretation of these data for regional radiometric anomalies is summarized in a report for each $1^{o}x2^{o}$ NTMS quadrangle in the study area.

Table 3-1 summarizes the availability of NURE data for the NTMS quadrangles that comprise the study area.

Information supplied by the BLM included:

- Claims information, and claims recordation data current as of August, 1982, were provided by the BLM State Offices in Oregon, Idaho, and Nevada. Data for all claims that occur within the GRAs were collected by TERRADATA and were used to generate claims density maps on which the number of claims per Cadastral Section were plotted. The claims density map for this GRA is given in Section 3 of of the individual GRA technical reports.

TABLE 3-1

Available NURE Data

QUADRANGLE (NTMS 1°x2°)	FOLIO	HSSR	ARMS
Adel	No	Yes(6,9)*	Yes(7)
Baker	Yes(8)	Yes(6,9)	Yes(10)
Boise	No	Yes(6,9)	Yes(11)
Bend	No	No	Yes(12)
Burns	No	No	Yes(12)
Canyon City	No	No	Yes(12)
Crescent	No	No	Yes(12)
Elko	Yes(15)	Yes(14)	Yes(13)
Jordan Valley	Yes(16)	Yes(17)	Yes(18)
Klamath Falls	Yes(19)	Yes(20)	Yes(21)
McDermitt	Yes(22)	Yes(23)	Yes(24)
Twin Falls	No	Yes(25)	Yes(26)
Vya	Yes(27)	Yes(28)	Yes(29)
Wells	Yes(30)	Yes(23)	Yes(31)

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* In this report, citations are superscripted numbers. They refer to bibliographic entries listed in Appendix A, References Cited.

These data were used to indicate the extent of past mineral exploration activity. Past activity may be an important criterion in resource evaluation. All claims within the study region are unpatented; lease plats and claims recordation data provided by the BLM show no patented claims within any of the WSAs.

- Lease plats for oil and gas, geothermal, and materials sites. These plats depict the leases for these different commodoties; they indicate past exploration activity and/or some interest in the resources of the region. These data may be an important critera in resource evaluation. Unless otherwise stated in the individual reports, lease data cited are for oil and gas only.

- Aerial photographs. These were used to help identify potential geologic hazards and to locate possible alteration zones within the WSAs.

- Other pertinent documents such as the Wilderness Inventory: Oregon and Washington(32); reconnaissance Geochemical Stream Sediment Survey of the Hawks Mountain and the Lone Mountain Areas, Harvey County, Oregon (33); and Paleontological Sites in Oregon(34).

Other sources of information used in the evaluation of the GEM resources in this study include:

- State geothermal maps and occurrence maps(35, 36, 37, 38, 39, 40, 41, 42)
- State geological survey publications(e.g., 43, 44, 45, 46, 47 48)
- USGS geological map indices and geologic maps(49,50,51)
- All available 7.5' and 15' series topographic maps
- Evaluation of state lands in Oregon(52).
- Pertinent government and private sector documents and publications (see bibliography in BLM District GRA master file and specific references cited in Appendix A).
- Idaho Oil and Gas Exploration Map(53)
- Mines and Prospects 1°x2° NTMS maps(54,55)
- Geologic Hazards map(56).

3.2 TASK 2: COMPILATION OF DATA AND ORGANIZATION OF DATABASE

In order to make the enormous amount of available information more directly usable by the panelists (and the BLM personnel later), the project area was subdivided into 27 GRAs (see Figure 1-1). As defined by the BLM, a GRA is an area that contains at least one WSA that, at a scale of 1:250,000, fits on an 8½"X11" sheet of paper, after having

made due allowance for margins. No GRA boundary may cross a WSA boundary. As much as possible, and within these size constraints, the boundaries of the GRAs were defined on the basis of logical geologic subdivisions. Each GRA was named after a dominant physiographic feature contained within its boundaries. All defined GRAs were assigned a representative number. The number scheme contains the following elements:

- A two-letter state designation (OR, NV, ID)
- A three-digit BLM District designator, and
- A two-digit serial number.

For cases in which a GRA occurs in two districts, the second and third numbers of the district identifier represent the two districts involved.

WSAs are identified by the BLM with a name and a number. The name is taken from a prominent physiographic feature within the WSA. WSA number identifiers consist of two numbers separated by a hyphen: The first number is indicative of the BLM district whereas the second number is a serial number within that district.

GRAs serve as devices for organizing and compiling the data gathered in Task 1. All data and information gathered during Task 1, as well as the reports of the panelists generated for Task 3, are incorporated into GRA files. Where materials pertinent to all GRAs within a given BLM district are present, they are located in a "master" GRA file for that district. All other GRA files within a district make reference to the material in the BLM District master GRA file.

Pertinent materials accumulated under Task 1 were distributed to the appropriate expert panelists for review and were incorporated in their evaluation. These include:

- Aerial photographs;
- Computerized bibliographies;
- Lease plats for oil and gas, geothermal, and materials sites;
- Claims information;
- NURE, HSSR and ARMS reports;
- NURE folios, geologic maps, occurrence maps, pseudo-contour maps, PRRs and UORs;
- State geothermal maps and occurrence maps;
- CRIB and MILS data;
- State geological survey publications;
- USGS geologic map indices, geologic maps, and preliminary land classification maps;
- All available 7.5' and 15' series topographic maps;
- N.S. Wagner's evaluation of Lands in Oregon;
- 1:250,000 scale geologic and topographic maps of the GRAs;

- State oil and gas exploration maps;
- Mines and Prospects $1^{\circ}x2^{\circ}$ NTMS maps;
- BLM supplied documents; and
- Pertinent governmental agency and private sector documents and publications.

3.3 TASK 3: ANALYSIS AND INTERPRETATION OF DATABASE

A multidisciplinary approach was used in the assessment of GEM resources for this project. In as much as it is unrealistic to expect any one individual to be knowledgeable about all the commodities evaluated in this project and to be knowledgeable about the general geology of the region as well, it was decided to use a team of experts for the evaluation. The experts used in this project were selected first for their commodity specific knowledge and expertise and secondarily for their familarity with the geology of the project area. By using the panel-of-experts concept, the BLM insures maximum efficiency and completeness of the project. The commodity specific knowledge of the panelists in conjunction with their geographic expertise provides an added dimension to the project that would not have been available using another method. Using the expert-panelist approach is consistent with the recommendations made by TERRADATA(57) and by the Committee on Mineral Resource Evaluation, National Research Council(58).

Each of the panelists reviewed the pertinent maps, literature, and data in the GRA files that were forwarded to them, added information from his personal files, and analyzed and interpreted the data in light of identifying environments favorable for the occurrence of GEM resources. Their interpretations were restricted to the GRAs, even though each considered the geology of the GRAs with respect to the regional geologic framework. For example, environments favorable for oil and gas were interpreted in light of the major tectonic framework and the resulting sedimentary environments within the region. Where favorable geologic environments, determined from a regional analysis, were thought to underlie a GRA, the GRA was designated favorable for the occurrence of oil and gas. Similarly, the presence and distribution of known occurrences and/or mineral belts external to the GRAs were important considerations in evaluating GRA's for the occurrence of environments that may potentially contain metalliferous deposits. Though few known mineral belts lie within the GRAs of this study, their presence, orientation, and proximity played an important part in the assessment of the metallic GEM resources in the area.

By studying the available data and applying pertinent recognition criteria, the panelists were able to identify environments favorable for GEM resources. Where the environment(s) did not underlie an entire GRA the panelists outlined the favorable environments on 1:250,000 scale maps. These maps are included in Section 2 of each GRA report and are in the GRA files. Only those environments that are within, or partially within contained WSAs are included on the maps. In addition to outlining favorable geologic environments, each panelist summarized his findings in a report that gives the geologic rationale for delineation and determination of the favorable environments. The essential conclusions of these reports are summarized in the GRA reports. The panelists' reports are included in their entirety in the GRA files. The land classifications as defined by the BLM are given by each panelist in these reports (see below for a discussion of land classifications).

Identification of favorable geologic environments was based on the panelists knowledge of the areas and on their commodity-specific expertise. Using differing recognition cirteria, the panelists interpreted the available data and information in light of potentially favorable geologic environments. The essential cirteria for the different commodities and a general discussion of the different GEM resources are given below.

3.3.1 Metals Resources

Deposits of metal ores may occur in any of six general environments. They may occur as magmatic concentrations, porphyry deposits, supergene enrichments, pegmatites, placers, and hydrothermal, contact metamorphic and/or metasomatic replacements. Recognition criteria for the six general environments differ widely. They are summarized by Bullock and others(59) and by TERRADATA(57). The tectonic and structural settings, the nature of the host and associated rocks, the type and extent of alteration, and the proximity and geologic similarity to known deposits or mineral trends are important recognition criteria. For example, the tectonic setting is an especially important criterion for the occurrence of porphyry deposits. Porphyry deposits often occur in associaton with island-arc environments. Associated rocks in an island-arc setting include diorite, tonalite, and granodiorite, whereas quartz monzonites and granites are rocks associated with continental crust settings. Alteration may exist in concentric zones around an intrusive source, depending on the degree of homogeniety of the host rock, the amount and orientation of fractures, and the erosional history. Hydrothermal deposits are commonly found in mobile belts and are characterized by

argillization, propylitization, silicification and/or hematitic alteration. They are commonly accompanied by retrogressive metamorphism. Their geometries are generally structurally controlled.

Another criterion used in the metallic resources evaluations in this project was the geographic relation and the geologic similarity of the study area to known metallogenic provinces, mineral belts, and mines, prospects, and occurrences(60).

Geophysical data, including magnetic, conductivity, gravimetric, and magnetotelluric surveys, were of somewhat limited use for this study because of the reconnaissance nature of these studies. The small deposits anticipated on the basis of models of known local occurrences would not be located by such reconnaissance-level surveys. Detailed geophysical surveys may be warranted in some of the GRAs prior to final land-use decisions, however.

3.3.2 Oil and Gas Resources

Fundamental geologic criteria upon which favorability evaluations for the occurrence of oil and gas may be based are the tectonic framework and the resultant depositional environments. Oil and gas accumulations are generally restricted to basins, either depositional or structural, and are dependent upon the communication between potential resource rocks and potential reservoir rocks(61). Of prime importance in this region is the Late Paleozoic to Late Messozoic sedimentary environment and the boundary of the Tertiary lacustrine environment(62). Marine and lacustrine environments are generally favorable for the generation and accumulation of hydrocarbons. Areas that contain these units but which have been extensively faulted or metamorphosed, however, may not be favorable because of the possible loss of hydrocarbons to the earth's surface.

Another geologic factor that could be locally detrimental to oil and gas preservation, is the extent and proximity of significant igneous activity. Igneous activity may cause hydrocarbons to be volatilized and to escape. Shows of oil and gas in test holes near the study area are important criteria. Such indications do not, however, indicate potential reservoir size. Newton(62) qualifies favorability on the basis of such shows, and inferred geologic environment (depositional environment and subsequent geologic activity).

3.3.3 Oil Shale and Tar Sands Resources

The entire project area has a low favorability for the occurrence of oil shale and tar sands. This evaluation is based on several criteria, the first of which is the inferred geologic environment. Oil shale commonly occurs in Tertiary sediments that were deposited in lacustrine environments. Such environments were not entirely lacking in the project area, but where they did exist, conditions conducive to the generation of a significant amount of kerogen were not effective for a long enough period of time. Tertiary ecosystems in the region were not stable because of the tremendous amount of associated volcanic activity and the influx of volcanic ejecta. Hydrocarbon-producing systems did not have sufficient temporal continuity to create significant deposits. Second, local volcanism was detrimental to oil shale accumulations. Thick ash flow sheets and intrusive activity could effectively cause kerogen production to cease; they also could drive off pre-existing kerogen accumulations. A third, important criterion for favorability of oil shale and tar sand environments is the occurrence of known deposits within the region. Minor amounts of oil shale and oil-impregnated sand have been found in the Humboldt Formation in northeastern Nevada and in the Payette Formation in southeastern Oregon, respectively(63,64,65). However, there are no known occurrences in or near any of the GRAs within this project area.

3.3.4 Geothermal Resources

Evaluation of geothermal resource potential within an area is based on two general types of information:

- directly observable data and inferences based on direct observation; and
- the results of laboratory analytical processes(66).

The first type of information includes surface phenomena that indicate resources at depth (such as hot springs, geysers, fumaroles); a relatively young volcanic terraine; hydrothermally altered rocks; major faults and fractured areas, and topographic position (e.g., the top of a horst or along the base of a fault-line scarp). Laboratory criteria include analysis of electrical resistivity studies, gravity studies, magnetic surveys, ground-noise measurements, bore-hole temperature gradient data, regional heat-flow maps, seismicity, magnetotellurics and infra-red sensing. Geochemical data from thermal waters, specifically Na/K ratios and measurements of the free hydrogen ion concentrations are commonly used as indicators of reservoir temperatures.

No single criterion can be used to establish the favorability of a given area for geothermal resources. Collectively, the criteria may provide strong indications of potential resources. Actual measurements can only be determined by drilling and production testing. The evaluation of geothermal resource potential in the project study areas has been orientated principally toward thermal sources of at least 300°F. This is the minimal temperature of water that could be used for generating electric power (under current technological constraints). However, consideration was also given to lower temperature resources, those that could be used for space heating. Direct-use potential has been noted where pertinent.

3.3.5 Uranium and Thorium Resources

Evaluations of the GRAs for environments favorable for the occurrence of deposits of uranium are based largely upon data acquired from NURE (see Section 3.1). Recognition criteria described in Mickle and Mathews(67) and summarized by Mathews and others(68) and by TERRADATA(69) were used for the assessment of uranium and thorium potential GEM resources.

Essential criteria used in the evaluation of the GRAs for uranium potential are of two general types:

- regional geologic character; and
- specific litho-mineralogic attributes.

Regional geologic character includes all those criteria that are defined on the greater-than-outcrop scale. Included here are such factors as tectonic setting, geometry of potential hosts, radiometric and/or geochemical anomalies over a relatively large area (i.e., not point anomalies), known occurrences and their proximity and geologic similarity to the study area, evidence of potential uranium source rocks and their relations to prospective host rock units.

Specific litho-mineralogic attributes include the outcrop-scale phenomena such as degree, extent, and type of alteration, and the lithology and mineralogy of potential host rocks. The specific criteria used to identify potentially favorable geologic environments differ according to the type of environment sought. Although a cosmological approach was used in this evaluation, the specific models used as guidance were often dictated by either the nature of known uranium occurrences in the region or by the general geologic

character of the study area. Work done previously by the DOE (and its predecessors such as the Atomic Energy Commission and the Energy Research and Development Administration) was useful in evaluating uranium favorability(70,71).

The available data also were interpreted in light of environments favorable for the occurrence of throium deposits using the recognition criteria given by TERRADATA(57) and Mathews(69). Major emphasis was placed on known thorium occurrences (none are known in the study area). Other thorium recognition criteria are somewhat vague and are not definitive. No environments within the project area were determined to be favorable for the occurrence of thorium deposits.

3.3.6 Coal Resources

The basic criterion used to evaluate the GRAs in this project for environments favorable for coal deposits is a regional appraisal of the Mesozoic and Tertiary depositional environments. Because the only significant continental deposits in the project region are Late Cretaceous and Tertiary and because the concurrent volcanic activity was detrimental to the development of significant coal deposits, the potential for coal in this area is quite low. Specific recognition criteria are summarized by Damberger(72) and TERRADATA(57). The chances that coal or carbonaceous materials formed in the project area are remote. Accumulation of carbonaceous materials in sufficient amounts to form coal or lignitic deposits requires a climate conducive to abundant plant growth; a shallow, swampy euxinic depositional environment; a subsequent source of sediments to isolate the carbonaceous material and considerable time for the coalification process to operate. For all of these factors to have operated properly for a long enough time in an area of long-term and wide-spread volcanism is unlikely. Such an environment could have possibly occurred in restricted localities, where thin deposits could have formed and could have been preserved. In many cases, however, air-borne and/or water-transported volcanic ash was transported into these areas during the period of vegetative accumulation. Adulteration by ash and silt lowers the "as received" BTU content below the point where the "coal" will not even burn. In addition, the depositional environment would have to have been sealed rapidly with sediments thick enough to prevent incineration by subsequent lava flows.

Any coals formed prior to the onset of Tertiary volcanism would in all likelihood be so deeply buried and faulted as to render them either inaccessible or economically unattractive.

3.3.7 Industrial Minerals Resources

Commodities used in the construction industry such as sand, gravel and crushed stone, compose over half the quantity and value of what are collectively referred to as "industrial minerals." Because these resources have a low value to volume ratio and, because large quantities are consumed, the sources of these materials must, in general, be close to the market. Given current economic conditions and demographic relationships, none of the WSAs in the project region contain economically viable sand and gravel resources. This situation could change, however, with the initiation of a major construction project near one or more of the areas. If this were to happen, potential sand and gravel resources in the WSAs could be a viable source of construction material. All of the GRAs within the project area contain potential sand and gravel resources. This evaluation is based on geologic criteria characteristic of sand and gravel deposits.

Sand and gravel deposits occur primarily as Quaternary alluvium along stream channels, flood plains, alluvial fans and terraces. Older deposits of sand and gravel generally are not favorable because they often are too deeply weathered to meet consumer specifications. Quaternary sands and gravels occur in every GRA in the project area. Perennial streams that are not actively down-cutting have the greatest potential for sand and gravel accumulations, specifically areas in which the streams are reworking Quaternary valley fills. Perched terrace gravels may occur; these represent aggradational episodes in stream evolution.

Beach strands and playa margins compose a second potentially favorable environment for the occurrence of sand and gravel. These are common in many of the study areas. Wave actions, long shore currents and the wind can effectively sort beach deposits by selectively winnowing the fines and less resistant mineral grains. Dunes developed along old beach strands could contain a large quantity of sand. Beach gravels and sands of Miocene to Recent age may occur along ancient shorelines, beach ridges and terraces.

Lease plats that contained pertinent materials sites were used as sources of"occurrence" information. All known materials sites were for road metal or were aggregate borrow-pits located near prominant roads and highways.

Potential alluvial fan-related deposits are likely in GRAs that are in the Basin and Range Province. Potential colluvial deposits, useful as fill, occur along the base of many of the oversteepened slopes, cliffs, and bluffs in many of the GRAs.

Geologic and topographic maps of the GRAs indicate potential Quaternary-Recent alluvial and/or beach environment deposits in every GRA.

The potential for other industrial minerals, including limestone, bentonite, clinoptilolite, diatomite, perlite, barite, fluorite, phosphate, and turquoise was investigated for each GRA. The types of criteria by which these evaluations were made include the inferred geologic environments, occurrences, and/or proximity to known deposits. For example, an area is considered favorable for limestone deposits when it is postulated to contain Paleozoic marine carbonate sequences. A lesser degree of favorability for limestone is ascribed to an area in which only post-Paleozoic lacustrine carbonate units occur. However, the lacustrine strata are often favorable for the occurrence of diatomite. Bentonite and clinoptilolite are diagenetic alteration products common in many tuffaceous sedimentary sequences. Perlite or hydrated glass is found in basal vitrophyre portions of rhyolitic volcanic flows and ash flow tuffs. Tuffaceous sources for bentonite and clinoptilolite may occur within lacustrine volcaniclastic environments. Fluorite commonly occurs as a product of hydrothermal activity and exists in both vein-type and disseminated deposits associated with intrusives. Fluorite is a common gangue mineral in metalliferous deposits. Barite often occurs as replacement bodies in carbonates. It also may occur with optical calcite in concretions in shale beds. Phosphate is used primarily in commercial fertilizers and occurs in Late Paleozoic marine sedimentary deposits. The occurrence of lateral equivalents of the Permian Phosphoria Formation is a key geologic criterion for determining the favorability of this resource.

Information pertinent to the evaluation of the GRAs for all industrial commodities comes from the personal knowledge of the expert panelist(73), discussions with other experts and various publications(41, 74, 75, 76, 77, 78, 79, 80).

3.3.8 Paleontological Resources

The assessment of paleontological GEM resources differs from other commodities in that these resources generally are not of economic or strategic importance. The criteria for determining paleontological resource potential within a given GRA area are based on the

suitability of the lithology for preservation, the depositional environment, the geologic history as interpreted from the age and lithology, and the percentage of the GRA that contains exposures of suitable units. The ranking is given on a scale of one to four, one being least favorable: Rank 1 = no to low potential, Rank 2 = low to moderate potential, Rank 3 = moderate to high potential (presence of resource considered probable), and Rank 4 = high potential (presence of resource considered certain). Coupled with this ranking system is an expression of the level of confidence that indicates the subjectivity inherent in interpreting the geology and the personal experience of the paleontologist within the area(81, 82). Data used for the evaluation of paleontological resources include documents from government agencies(34, 83, 84, 85), unpublished theses and reports(83, 86, 87), corporate reports(85), and professional publications(89, 90), as well as available geologic mapping(77).

3.3.9 Geologic Hazards

Geology as a resource includes geologic hazards such as unstable land, seismically-active areas, and volcanoes and volcanic activity. Areas of potential geologic hazards on Federal lands must be known, located, and managed to the maximum public benefit. Sources of information used to delineate geologic hazards include:

- U-2 high altitude photography for the western part of the Oregon GRAs
- LANDSAT imagery for all of Oregon, parts of northern Nevada and southwestern Idaho (false color imagery from the BLM and Oregon State University, Corvallis, Oregon)
- Color aerial photography supplied by the BLM
- USGS 7.5' and 15' series topographic maps
- Geologic, geologic hazard, structural geology, and geothermal maps.

The types of features indicated on the hazard maps are faults, faultscarps, landslides, and volcanic centers. This geologic resource does not fit logically into the BLM land classification scheme. Instead, geologic hazard maps for each GRA have been included in the respective GRA files.

3.3.10 Educational and Scientific Localities

None of the GRAs in the project study region contain significant educational and scientific localities (ESLs). Hundreds of questionnaires were sent out to solicit input on ESLs from the general public, governmental agencies, educational institutions, professional or quasi-professional organizations, individuals, and private industries. There were no responses to the questionnaries to indicate the existence of ESLs in any of the GRAs within the study region.

3.3.11 Classification System

It is important for the BLM's purposes in this project to maintain consistency in evaluations among the different commodities and among the different GRAs. This project is only one of six, all of which are evaluating GEM resources. It is important to maintain consistency among the different projects. Much of the BLM's organizational and management system is based on a consistent, reliable classification of lands under its jurisdiction. In order to adhere to these standards and to maintain consistency among commodities and GRAs, the BLM has devised a two-fold classification for the GEM resources: One for favorability and one for levels of confidence.

Favorability Classification

One of the principal purposes of this project is to classify the GRAs (and especially the WSAs) with respect to the potential for GEM resources. The favorability classification scheme is based in large part on the amount of specific information available. Enough information must be available to the panelists for them to make inferences regarding the likelihood that the process of mineralization had occurred in the study area. With sufficient evidence available to make inferences regarding mineralization and with occurrences either within or immediately adjacent to the study area, the favorability classification is elevated. With these factors plus the presence of mines or known deposits within or immediately adjacent to the study area (in similar geologic environments) the highest favorability class may be achieved. Using these guidelines, the BLM defines for this study four classes of favorability. These are:

Class 1:
The geologic environment and the inferred geologic processes do not indicate favorability for accumulation of mineral resources.

Class 2:
The geologic environment and the inferred geologic processes indicate low favorability for accumulation of mineral resources.

Class 3:
The geologic environment, the inferred geologic processes, and the reported mineral occurrences indicate moderate favorability for accumulation of mineral resources.

Class 4:
The geologic environment, the inferred geologic processes, the reported mineral occurrences, and the known mines or deposits indicate high favorability for accumulation of mineral resources.

As can be seen from these definitions, this classification depends in large part upon the pressence of known occurrences or deposits. Thus, a favorable environment that has no known occurrences or deposits must be classified as having low favorability (Class 2).

Classes of Levels of Confidence

Paired with the favoribility classes is a four-fold classification that describes the level of confidence regarding the GEM resources of the environment. It is based on the amount and quality of information available. Confidence level classes provide an estimation of the quality of the data used in the evaluation. This is directly reflected in the level of confidence in the favorability classification. A favorability class assigned to a given environment can be tempered by a statement of confidence. This confidence statement reflects the quality of the data that went into the favorability determination. The confidence level classes and their definitions are:

Class A:
The available data are either insufficient and/or cannot be considered as direct evidence to support or refute the possible existence of mineral resources within the respective area.

Class B:
The available data provide indirect evidence to support or refute the possible existence of mineral resources.

Class C:
The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.

Class D:
The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

With these two classification schemes, each environment within a GRA may be classified according to the degree of favorability as well as the level of confidence in that

classification. For example, an area classified as 2C is one in which the overall geologic aspects of the area suggest a low favorability for the occurrence of GEM resources based on a minimal amount of direct evidence.

It should be noted that these classification schemes have some limitations when they are applied to paleontological resources, geologic hazards and ESLs. Although important resources for the BLM, these three GEM resources are not "commodity oriented." They are not the same types of resources as the other commodities. As such, concepts of "inferred processes of mineralization" have little meaning. However, occurrences can be noted and the favorability classification can be assigned. The amount and quality of available information may be used to assign a confidence level classificaiton.

Each environment within the GRAs has been classified by the expert panelists according to this scheme. The classifications are discussed in Section 2 of each GRA technical report.

3.4 TASK 4: FIELD VERIFICATION

After preliminary identification and classification of environments favorable for the occurrence of GEM resources was made, TERRADATA and BLM personnel selected from a list of nominees made by the panelists, those environments that were to be verified in the field. Selections were made first from the list of environments recommended for field verification by the panelists and secondly from environments suggested by BLM personnel. GRAs selected for verification were those in which the contained environments were potentially favorable for more than a single GEM resource. Table 3-2 summarizes the environments verified and the commodities for which they were investigated.

TABLE 3-2

GRAs Selected For Field Verification

NUMBER/NAME	COUNTY	STATE	COMMODITIES
NV-010-03 Rough Hills	Elko	Nevada	Metals, Geothermal
NV-010-05 Cedar Ridge	Elko	Nevada	Metals, Geothermal
ID-010-09 Big Jack's Creek	Owyhee	Idaho	Metals, Industrial Materials
ID-010-11 Owyhee River	Owyhee	Idaho	Metals, Industrial Materials
OR-020-13 Aldrich Mountain	Grant	Oregon	Metals
OR-030-17 Cedar Mountain	Malheur	Oregon	Metals, Oil Shale, Mercury, Geothermal
OR-020-21 Pueblo Valley	Harney	Oregon	Metals, Mercury, Geothermal
OR-010-23 Mule Springs Valley	Harney	Oregon	Metals, Zeolites
OR-010-24 Guano Valley	Lake and Harney	Oregon	Metals, Geothermal
OR-010-25 Crump Lake	Lake	Oregon	Metals, Geothermal

The purpose of field verification is to determine if the information from the literature is accurate and to gather additional relevant information that may have a bearing upon the assignment of a favorability classification. It has the essential purpose of gathering geologic information that will help decrease the uncertainty regarding whether a favorable geologic environment exists in the area. (See classification discussion in Section 3.3.11.) Those geologic environments known to contain deposits (or bona fide occurrences) were not selected for field verification because of the low uncertainty regarding the environment. Field verification of such environments would add little to the assessment. Many GRAs, however, had insufficient information regarding geologic attributes from which the panelists might infer the presence of a favorable geologic environment. In these instances, there is a fairly high degree of uncertainty regarding the presence of a favorable geologic environment. Such GRAs were candidates for field verification.

Field verification of the selected GRAs was carried out by Mr. R.E. Corcoran, the expert panelist for field verification. The field investigation was of the reconnaissance-type; no detailed mapping or sampling was undertaken(91). The process of field verification consisted of a field visit to each of the selected GRAs. A reconnaissance-type geologic investigation was undertaken for evidence in support of the favorability classification. This consisted of verifying mapped rock types, seeking evidence that might indicate the mineralization process could have been operative in the area (e.g., alteration, veining, contact metamorphism, etc.), studying the lithologic character of mapped units (e.g., whether limestone contained chert or pseudochert nodules, pyrite concretions, floating quartz grains, etc.), and verifying whether reported geologic criteria were actually present. Because of the reconnaissance nature of the verification, and because only a single day was spent on each GRA, the entire GRA could not be traversed. Care was taken to see as many different geologic units and geologic settings in as many different areas within each GRA as possible. This was done by driving into or, more commonly, adjacent to the GRA and making traverses into the area. Pebbles and cobbles in stream channels that drain the interior of the GRA were studied for evidence of alteration in the GRA interior.

Results of field verification are given in a report contained within the appropriate GRA files. The report details the observations pertinent to favorability. It was added to the database and, when relevant, was given to the expert panelists for re-evaluation (Task 5).

3.5 TASK 4A: GEOCHEMICAL STREAM SEDIMENT SAMPLING AND ANALYSIS

A stream sediment sampling and geochemical analysis program was undertaken in order to better establish the geochemical character of three areas in southeastern Oregon that, by an initial estimate, have potential for being anomalous. The sampled areas were defined by the COAR and contain all or portions of four GRAs. The BLM specified the elements which were to be analyzed and their detection limits. These are given in Table 3-3.

3.5.1 Sampling Procedure

The sampling techniques used in this study were modeled after the methods used by the Savannah River National Laboratory for the NURE program(92). Sampling sites that were selected prior to field work were carefully located and studied to make certain that only uncontaminated water-transported sediments were available. For consistency and uniformity, it was planned that dry sediment samples would be collected whenever possible. However, because of inclement weather, nearly all samples were wet. They were dried later at low temperature in the laboratory prior to sample preparation (sieving to -80 mesh).

Two medium sieved samples (greater than 2mm) of 10 lbs each were collected at each site. One was to be further sieved to -80 mesh; the other was to be panned for heavy mineral concentrates. The samples were taken from three to ten grab localities at each site. Extreme care was taken to avoid including soils, wind blown materials or other contaminants. Careful attention was paid to the possible occurrence of sources of contamination upstream from the sampling site. Such sources of contamination include upstream mine adits, tailings, dams, roads, stockyards, salt licks, etc.

Because of time constraints and within the necessary provisions of avoiding contamination, all samples were taken from as close as possible to the access road (on the upstream side). Each sample was identified with a number that included the WSA number of the drainage, a consecutive serial number and the type of sample collected (SS = sieved stream sediment; HM = heavy mineral concentrate). Sample 3-53/02-SS, for example, is a sieved sediment from the second sampling site in WSA 3-53. Sample numbers were placed on the outside of the sample bags, on paper inside the sample bags, on flagging tape left to mark the site, and on the field maps to indicate sample locations.

TABLE 3-3

Geochemical Analysis Summary

ELEMENT	ANALYTICAL METHOD	DETECTION LIMIT
Ag	AA	0.1
As	Special	2.0
Au	Fire Assay	5 ppb
Ba	XRF	15.0
Be	Special	0.5
Co	AA	1.0
Cu	AA	1.0
Hg	Vapor	5 ppb
Mn	AA	1.0
Mo	AA	1.0
Ni	AA	2.0
Pb	AA	2.0
Sn	XRF	1.0
U	Fluormetric	0.1
W	Special	2.0
Zn	AA	1.0

AA = Atomic absorption
XRF = X-ray fluoresence
Special = AA using multi-acid digestion

Samples were collected and sieved using non-contaminating equipment (plastic-ware and stainless steel). Samples of the -80 mesh fraction were delivered to Bondar-Clegg for analysis.

3.5.2 Analytical Procedure

Stream sediment samples (-80 mesh) were analyzed by Bondar-Clegg for the elements listed in Table 3-3. The analytical method used and the detection limits are also given. Inasmuch as the geochemical stream sediment sampling program was restricted to specific GRAs, the resultant data are incuded in the appropriate GRA reports and GRA files. The GRAs included in this program are:

GRAs Selected For Stream Sediment Analysis

Number	Name	Location
OR-050-14	Gerry Mountain	Deschutes & Crook Counties, Oregon
OR-030-16	Lake Owyhee	Malheur County, Oregon
OR-023-18	Sheepshead Mountain	Harney & Malheur Counties, Oregon
OR-023-19	Alvord Desert	Harney & Malheur Counties, Oregon

3.6 TASK 5: RE-INTERPRETATION OF DATABASE

Information obtained during field verification was added to each respective GRA database. Observations and conclusions drawn during field verification were forwarded to the expert panelists for review. These new data were reviewed by the appropriate expert panelist in light of possible modifications in their classifications. Where these data led to a classification reassignment, the appropriate panelist submitted an addendum to his report in which the geologic rationale for the reassignment was included. These addenda were added to the appropriate GRA files and were incorporated in the favorability discussions of the GRAs given in Section 2 of each GRA technical report.

Re-interpretation of the database in light of the newly acquired information is an essential process in GEM resources evaluation. This insures a thorough review of the information obtained during field verification and an updating of the basic database. In this manner, the BLM is assured that the evaluations given in Section 2 of the GRA technical reports are based on the most recently acquired data.

3.7 TASK 6: PREPARATION OF THE GRA TECHNICAL REPORTS

The final task of this project is the preparation of a technical report for each GRA. The essential contents of each report are:

- A description of the geologic setting
- A discussion of the energy and mineral resources
- A presentation of the classification of land as defined by the BLM, regarding its potential for containing GEM resources, and
- Recommendations regarding how the land classification might be improved.

An important consideration in the preparation of the GRA reports is the added emphasis given to strategic and critical commodities. These commodities, listed in Table 3-4, are of particular interest in the evaluation of GEM resources in the project region. These commodities are currently being stockpiled in the United States, or are materials for which the United States depends on foreign sources for at least 50 percent of the total domestic consumption. Environments favorable for the occurrence of any of these commodities are of prime importance and are addressed specifically in Section 2 of the GRA technical reports.

TABLE 3-4

Strategic And Critical Minerals And Metals(93)

COMMODITY	STRATEGIC RATING	COMMODITY	STRATEGIC RATING
Antimony	SX	Manganese	SX
Asbestos (chrysotile)	SX	Mercury	S
Bauxite (refractory)	SX	Mica (sheet)	SX
Beryllium	S	Nickel	SX
Bismuth	SX	Platinum (group)	SX
Cadmium	SX	Potash	X
Chromium	SX	Quartz Crystals	S
Cobalt	SX	Silver	S
Columbium	SX	Strontium	X
Copper	S	Tantalum	SX
Diamond (industrial)	SX	Tin	SX
Fluorspar	SX	Titanium	S
Graphite	SX	Tungsten	SX
Iodine	SX	Vanadium	S
Lead	S	Zinc	SX

X = Current import reliance of 50% or more
S = On current stockpile list

- APPENDIX A -

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- APPENDIX B -

Biographies

BIOGRAPHIES

TERRADATA PERSONNEL

Dr. Geoffrey W. Mathews, Project Director

Dr. Mathews, Ph.D., is Vice President of TERRADATA and Manager of TERRADATA's Denver Office. Prior to joining TERRADATA, Dr. Mathews was Assistant Director of the Geology Division for Bendix Field Engineering Corporation. While there he directed and coordinated the activities of the Data Integration Group. This included the resource assessment process for all NTMS 1°x2° quadrangle evaluations. Dr. Mathews was principally responsible for the design of the elicitation procedure used to determine resource estimates and uncertainties. Six of the 13 1°x2° NTMS quadrangles within this study area were either assessed by Dr. Mathews or were assessed by personnel under his supervision. He was responsible for developing a classification system, recognition criteria and uranium occurrence models for NURE. He has specialized in quantitative evaluations of subjectively estimated qualitative resource assessments. Dr. Mathews also taught geology at Indiana University for ten years before joining Bendix Field Engineering Corporation. He was responsible for the integration of panelists' papers for TERRADATA's GEM standards project with the BLM.

Mr. Edwin H. Montgomery, Assistant Project Director

Mr. Montgomery is TERRADATA's Consultant on BLM Resource Assessment Methods for GEM resources. He is a private consultant offering advice in American mining law, government regulations and procedures, environmental assessments, land status, minerals leasing, mining claims, mineral inventory and mineral resource assessments. He was responsible for preparing a comprehensive proposal to revise the minerals input to the BLM's planning system, emphasizing mineral resource assessment methods. This involved a comprehensive review of former procedures and the conceptual development of levels of inventory, standards of data quality, and a rating scheme for mineral areas. He is very familiar with data collection and interpretation for the BLM's GEM resources inventories. Mr. Montgomery was a consultant to TERRADATA on the GEM resources inventory standards development project. He also has designed training programs and coordinated training of BLM specialists in mineral resource assessment methods. Mr. Montgomery was with the BLM for over 25 years.

Mr. William H. Blackburn, Project Geologist

Mr. Blackburn has a B.S. in Geology and two years of graduate study from Indiana University. He has an extensive background in methods of resource appraisal. Prior to joining TERRADATA, Mr. Blackburn was a key member of the Data Integration Group at Bendix Field Engineering Corporation. This group was responsible for developing classifications, recognition criteria, assessment methods, and interpreting HSSR and ARMS data for the NURE program. He assisted in developing procedures for estimating quantitative probabilities from subjective qualitative estimates regarding resource potential. Mr. Blackburn was instrumental in developing and carrying out the quadrangle assessment procedure used in NURE; he had sole responsibility for maintaining the NURE assessment database. He developed mineralogenic models in Washington, Colorado, and northeastern Wisconsin.

EXPERT PANELISTS

Professionals that served on TERRADATA's panel of experts for this project were chosen for their experience, knowledge, and reputation in the different GEM resource categories; because of their depth of knowledge regarding environments favorable for the formation of specific commodities, methods of recognizing such environments, knowledge of the general area, and their experience with literature and other sources of pertinent data and information.

Dr. Antonius Budding, Oil Shale and Tar Sands

Dr. Budding, Ph.D., is TERRADATA's Consulting Geologist for the assessment of oil shale and tar sands. Since 1956 he has been Professor of Geology at the New Mexico Institute of Mining and Technology and for the past ten years, he served as a consultant to the Los Alamos Scientific Laboratories. Dr. Budding has an ongoing research interest in kerogen-bearing lake beds, petroliferous black shales and tar sands. Dr. Budding is experienced in the geology and depositional and structural environments of the western United States, particularly in light of oil shale environments.

BIOGRAPHIES

TERRADATA PERSONNEL

Dr. Geoffrey W. Mathews, Project Director [illegible] and Manager of [illegible] Dr. Mathews, Ph.D., is Vice President of TERRADATA [illegible] Dr. Mathews was [illegible] Denver Office. Prior to joining TERRADATA, Dr. Mathews [illegible] the Geology Division for Dames' Field Engineering Corporation. While [illegible] and coordinated the activities of the Data Integration Center. [illegible] procurement process for all NURE [illegible] principally responsible for the design of the [illegible] resource estimates and uncertainties. [illegible] were [illegible] by [illegible] experience. He was responsible for developing [illegible] geologic and uranium occurrence modeling [illegible] evaluations of subjectively estimated endowment [illegible] also taught geology at Indiana University for [illegible] Engineering Corporation. He was responsible for [illegible] TERRADATA's [illegible] standards [illegible]

Mr. Joseph R. Montgomery, Assistant [illegible] Mr. Montgomery is TERRADATA's [illegible] GEM resources. He is a [illegible] government regulations and [illegible] leasing, mineral claims [illegible] responsible for [illegible] [illegible] a comprehensive [illegible] of [illegible] [illegible] [illegible] [illegible] Mr. Montgomery [illegible]

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Mr. Blackburn has a B.S. in Geology and two years of graduate study from Indiana University. He has an extensive background in methods of resource appraisal. Prior to joining TERRADATA, Mr. Blackburn was a key member of the Data Integration Group at Bendix Field Engineering Corporation. This group was responsible for developing classifications, recognition criteria, assessment methods, and interpreting HSSR and ARMS data for the NURE program. He assisted in developing procedures for estimating quantitative probabilities from subjective qualitative estimates regarding resource potential. Mr. Blackburn was instrumental in developing and carrying out the quadrangle assessment procedure used in NURE; he had sole responsibility for maintaining the NURE assessment database. He developed mineralogenic models in Washington, Colorado, and northeastern Wisconsin.

EXPERT PANELISTS

Professionals that served on TERRADATA's panel of experts for this project were chosen for their experience, knowledge, and reputation in the different GEM resource categories; because of their depth of knowledge regarding environments favorable for the formation of specific commodities, methods of recognizing such environments, knowledge of the general area, and their experience with literature and other sources of pertinent data and information.

Dr. Antonius Budding, Oil Shale and Tar Sands

Dr. Budding, Ph.D., is TERRADATA's Consulting Geologist for the assessment of oil shale and tar sands. Since 1956 he has been Professor of Geology at the New Mexico Institute of Mining and Technology and for the past ten years, he served as a consultant to the Los Alamos Scientific Laboratories. Dr. Budding has an ongoing research interest in kerogen-bearing lake beds, petroliferous black shales and tar sands. Dr. Budding is experienced in the geology and depositional and structural environments of the western United States, particularly in light of oil shale environments.

Mr. R.A. Corcoran, Field Verification

Mr. Corcoran is TERRADATA's Consulting Field Specialist. He has worked in numerous aspects of GEM resources in and around the project area for nearly 30 years. Mr. Corcoran is a former Director of the Oregon Department of Geology and Mineral Industries. While with the Department he was directly involved with resource studies of metals, non-metals, zeolites, industrial commodities, and oil and gas. He is a specialist in the field aspects of favorable geologic environments for many different commodities. He has studied and mapped in many of the specific areas that are included in this project. He has had direct field experience with several GEM resource commodities and their geologic settings in this region. He has studied and evaluated metal deposits, bauxite deposits, and petroleum potential and was instrumental in the development of intradepartmental studies on zeolites for the Oregon Department of Geology and Mineral Industries. Mr. Corcoran's lengthy, multi-commodity experience in this geographic area and his personal contacts with geologists and mineral companies in Oregon were valuable assets to this GEM resource study.

Dr. James Firby, Paleontology and Literature Search Coordinator

Dr. Firby, Ph.D., is Consulting Paleontologist to TERRADATA, and Associate Professor of Geology at the MacKay School of Mines, University of Nevada, Reno. He was Assistant Dean at the school for seven years. He has served as a consultant to several companies, including Inter Mountain Research, Woodward-Clyde, and Dames and Moore, on paleontological research. He also has been Principal Investigator, Director or Project Geologist on studies conducted for Lawrence Livermore Laboratory, Bendix Field Engineering Corporation and the United States Department of Health, Education and Welfare. Dr. Firby has performed a paleontological inventory for the Carson City, Nevada, BLM District. He is currently completing a paleontological characterization of the Elko and Winnemucca BLM Districts. The Elko District contains five GEM resource areas that are subject of this investigation. Dr. Firby is also an expert in the utilization of computerized literature search techniques. He performed the extensive literature search for this project using search strings developed from recommendations of key-words in-context made by TERRADATA personnel and panelists.

Mr. Ralph Mason, Coal

Mr. Mason, TERRADATA's Consulting Geologist for coal, has worked as Geologist, Deputy State Geologist, and State Geologist for the Oregon Department of Geology and Mineral Industries from 1943 to 1977. His areas of expertise are non-metals and coal geology in Oregon. For nearly 40 years Mr. Mason studied the geology of Oregon, with primary emphasis on the environments and occurrences of potential resources. He has published numerous professional papers dealing with Oregon's resources.

Mr. Richard Miller, Uranium and Thorium

Mr. Miller is TERRADATA's Consulting Geologist in uranium and thorium. Mr. Miller holds an M.S. in Geology from Stanford University. He has been employed by the U.S. Atomic Energy Commission, the Energy Research and Development Administration, and the U.S. Department of Energy for nearly 30 years. A field geologist and geological engineer, he has examined uranium mines and prospects, calculated uranium ore reserves, estimated potential uranium resources and prepared geologic reports in much of the Western United States. Mr. Miller was the DOE Regional Geologist for eleven years in Spokane, Washington, where he conducted field work and evaluation studies for the assessment of uranium resources in the Northern Rockies, the Columbia Plateau, and the Northern Basin and Range regions.

Mr. Vernon Newton, Oil and Gas

Mr. Newton, TERRADATA's Expert Panel Member for oil and gas has devoted most of his professional career to the study of oil and gas environments. He is a petroleum engineer/geologist specializing in petroleum exploration and development in Oregon and Washington. Mr. Newton has been involved with all aspects of petroleum, from exploration through the regulatory requirements for drilling, to the legislative activities governing oil and gas in Oregon. He has published numerous professional papers dealing with petroleum geology and resource appraisal, several of which are in the general areas of the WSAs of this project.

Mr. H.G. Schlicker, Industrial Minerals and Geologic Hazards

Mr. Schlicker is TERRADATA's Consulting Geologist for the assessment of industrial commodities and the delineation of geologic hazards. Mr. Schlicker has worked for the Oregon Department of Geology and Mineral Industries for 25 years, specializing in industrial minerals and geologic hazards. He has written several intradepartmental reports on zeolites, some of which have been put on open-file. As part of the zeolite

studies, Mr. Schlicker helped develop, and still maintains a collection of maps that denote all known zeolite occurrences in the Oregon portion of the project area. Of particular relevance to this project is his experience in geologic mapping and geologic investigation of the John Day area of Grant County, Oregon, an area that contains some of the WSAs evaluated in this project. Mr. Schlicker was involved in several studies of industrial mineral potential in Oregon. Included were studies and reports on sand and gravel, rock materials, and aggregate resources in Oregon. Some of these studies were done in southeastern Oregon, a major part of this project area. In addition to being an expert in assessing non-energy mineral resources, Mr. Schlicker also is an expert in engineering geology and in the evaluation of potential geologic hazards.

Dr. Paul L. Weis, Metals and Non-Metals

Dr. Weis, Ph.D., is TERRADATA's Consulting Geologist for the assessment of metals and non-metals. Dr. Weis worked for the United States Geological Survey for over 30 years, principally on projects directly related to mineral resources. He has more than ten years of experience in the estimation of mineral resource potential. His work with the USGS included duty as Staff Geologist, Office of Mineral Resources, in planning, coordination and general administration of resource appraisal programs in the West. Dr. Weis is author of more than 45 technical or scientific publications. His assignments with the USGS have involved mineral resource appraisals in the North Cascades Primative Area, Washington; the Salmon River Breaks Primitive Area, Idaho; Eagle Gap Wilderness and vicinity, Oregon; and the Garden Valley and Boiling Springs Quadrangles, Idaho. Dr. Weis also was involved in mineral and water resources assessments of Montana, Washington, and Oregon. In addition to general metal and non-metal resource appraisal, Dr. Weis' studies have focused on resources of uranium, graphite, asbestos, pegmatites, and base-metal deposits.

Dr. Walter Youngquist, Geothermal

Dr. Youngquist, Ph.D., is TERRADATA's Consulting Geologist for geothermal resources. Dr. Youngquist is a consulting geologist specializing in geothermal resources, Professor of Geology at the University of Oregon, consultant since 1973 to the Eugene Water and Electric Board on Geothermal resources, and Chairman of the State of Oregon Geothermal Task Force for the Alternative Energy Development Commission. He was technical manager for the cooperative private-United States Department of Energy Cascades geothermal drilling project. He is a member of the Geothermal Resources Council, and author of several papers on geothermal energy. Field experience includes

geothermal studies in all of the western United States, Peru, New Zealand, and the Philippines.

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